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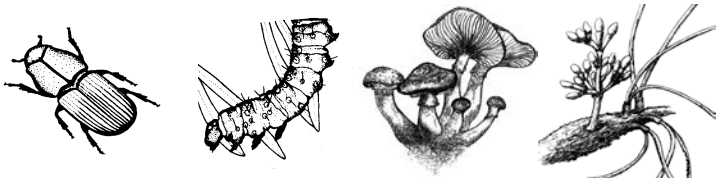

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CONE AND SEED INSECTS AT BIG FORK TREE IMPROVEMENT AREA

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Introduction

Insects that feed on cones and seeds are common in our forests and can often become "pests" in seed orchards where high value seed is collected from genetically superior trees. Douglas-fir and western larch trees at Big Fork Tree Improvement Area (TIA) are now producing valuable seed for reforestation. Demand for seed from east side Douglas-fir and mid- and high elevation western larch is high and the Big Fork TIA is expected to provide seed for a large portion of western and central Montana.

Low seed yields are occurring at Big Fork TIA and are at least partially due to Douglas-fir tussock moth and western spruce budworm outbreaks causing defoliation and weakening the trees as well as cone and seed insects damaging cones and consuming seeds. We report insects found during the summer 2012 and provide management options to reduce seed losses at Big Fork TIA in the future.

Methods

The Big Fork TIA is located on 80 acres north of Big Fork, Montana (PM, T.27 N., R.20 W., sec. 14). It was visited June 4-5 and August 28-29, 2012. During each visit, cones with evidence of insect frass or other damage were collected and either dissected on site or placed in rearing containers at the Coeur d'Alene Forest Health Protection (FHP) lab. Any insects emerging in the rearing containers were collected and identified. During the August visit, cones were examined from a lift truck for insects that feed externally on cones and other signs of insect damage. Numbers of damaged and undamaged cones for certain insects were tallied and percent damaged cones calculated.

To monitor the flight period of fir coneworms, (*Dioryctria abietivorella)*, Bill Crane, seed orchard manager, placed coneworm pheromone traps in five Douglas-fir and three western larch blocks

on June 2. Lures were replaced July 6 and both traps and lures replaced July 30. Coneworm moths caught were counted weekly through September 17.

Cones were operationally collected in late August and September and sent to the Coeur d'Alene nursery for seed extraction. A portion of these seed were x-rayed to determine additional damage by insects. Seed yield as pounds of seed per bushel of cones was determined.

Results

Insects Found

Western Spruce budworm

Western spruce budworm (*Choristoneura occidentalis*) was found defoliating the Douglas-fir and western larch blocks in the orchard and was the most abundant insect reared from damaged Douglas-fir and western larch cones collected June 5 (fig 1). Budworms were found to be a serious pest in Douglas-fir cones in 13 areas in Yellowstone National Park and throughout Montana, including the Flathead National Forest where Big Fork TIA is located (Dewey 1970). Dewey found that budworms damaged an average of 36-62% of Douglas-fir cones (range 9-98%) in two consecutive years. Budworm larvae have also caused severe damage in western larch cones in western Montana (Fellin and Shearer 1968).

Figure 1. Budworm larva in Douglas-fir cone at Big Fork Tree Improvement Area.

Western spruce budworms overwinter as young larvae. They typically emerge from hibernation from May to June. Douglas-fir cones can begin developing before lateral and terminal buds and are a good food source for newly emerging larvae. Larvae feed on cones from the time they emerge in the spring until they pupate. Larger larvae in late stages of development are voracious feeders and can damage more than one cone. Budworm larvae complete their development by mid- to late July and pupate within a cone or in the foliage nearby.

Figure 2. Coneworm frass on Douglas-fir cone.

Fir Coneworm

About 34% of cones examined from a lift truck in Douglas-fir block 7A contained fir coneworm frass (fig. 2). Fir coneworm adult moths were reared from Douglas-fir cones collected June 5. Fir coneworms were first caught in pheromone traps placed in

Douglas-fir orchard blocks on July 2 and in western larch on July 12 (fig. 3). Peak flights occurred in mid-July and late August to early September.

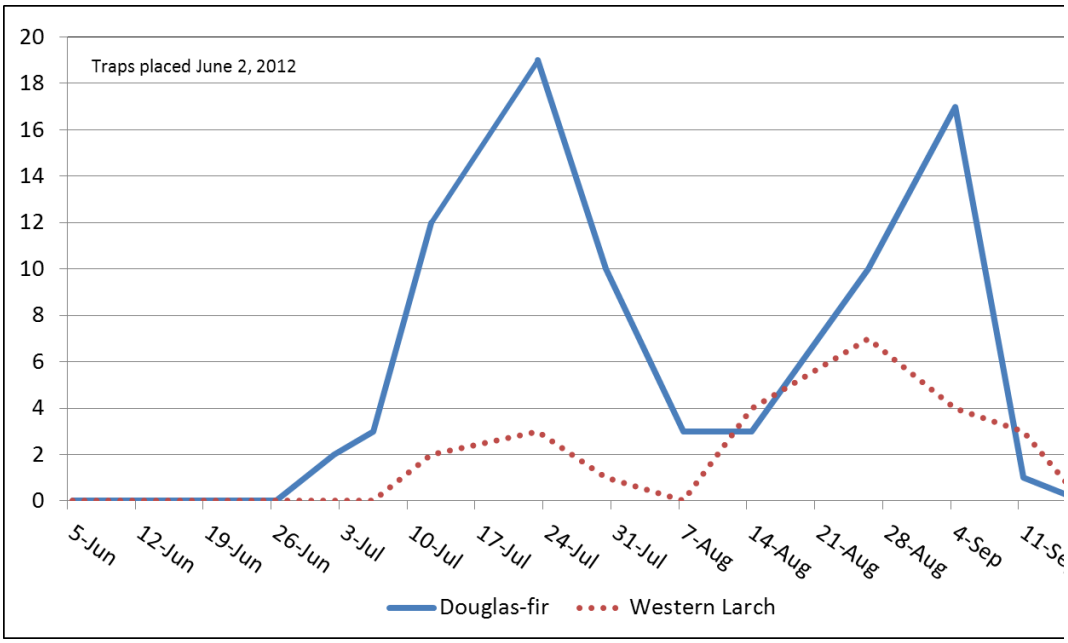

Figure 3. Coneworm trap catches at Big Fork TIA in Douglas-fir and western larch orchard blocks.

The fir coneworm has a broad host range. It has been found infesting true firs, Douglas-fir, many species of pine, spruces, western larch, and western hemlock in Canada, the northeastern United States, and in the west from Alaska to northern Mexico (Sopow et al. 1996). Their life cycle is variable but in general they have one generation per year. Adults begin flying in late spring and are active until late summer. Larvae begin feeding in June and can be found in cones throughout the growing season. Part of the population emerges as adults in the fall while others overwinter as larvae or pupae on the cone or in the duff (Whitehouse et al. 2011).

Western Conifer Seed Bug

Western conifer seed bugs (*Leptoglossus occidentalis*) have been observed feeding on Douglas-fir and several species of pine from British Columbia to Mexico (Koerber 1962). Adult seed bugs hibernate over the winter—often invading people's houses in the fall—and emerge in spring. They are strong fliers and are easily disturbed. Mating and egg laying occur in late May through early July. Eggs are laid in rows on needles. Seed bug nymphs look similar to adults only smaller and with more orange on their abdomens. They are gregarious, do not have wings, and do not fly. Both nymphs and adults feed on seed from the outside of cones. They have a long, sucking beak (mouthpart) that they insert through cone scales to a seed. Seed contents are dissolved by seed bug saliva and then consumed. Seed bug feeding causes partially filled or empty seeds. Damaged seeds are not viable and can be detected by radiography or biochemical marker based techniques (Lait et al. 2000, Bates et al. 2002).

Numerous seed bug adults and nymphs were found during examinations from a lift truck August 28 in western larch and in the Douglas-fir 7A block. Often multiple seed bugs were found on each individual cone examined (fig. 4). Radiographs of extracted seed revealed partially filled

seed damaged by seed bugs (fig. 5). Many empty seed were also found. Empty seed could be due in part by seed bug damage or by lack of pollination but the cause cannot be discerned by radiographs (Bramlett et al.1977).

Figure 4. Adult seed bugs found on Douglas-fir cone (left) and western larch cone (right). Seed bug nymph (center) on Douglas-fir cone.

Figure 5. Radiograph of Douglas-fir 7A seed showing partially filled seed damaged by seed bugs and seed chalcid larvae inside seed.

<u>Douglas-fir Seed Chalcid</u>

Radiographs of seed from Douglas-fir block 7A revealed numerous seed infested with Douglas-fir seed chalcid (*Megastigmus spermotrophus)* larvae (fig. 5). Externally, infested seeds look identical to normal seeds and have no visible damage.

The Douglas-fir seed chalcid emerges in late May and June from infested seed in cones or seed on the ground (Johnson and Hedlin 1967). When

the adult emerges, an obvious clean-cut exit hole can be seen on the external seed coat. The flight period lasts for about one month. The female inserts her ovipositor through the scales of young cones to deposit an egg in the developing seed. Larvae remain in the seed consuming the entire contents. It pupates in the seed. A portion of the population can remain in diapause in the larval stage for more than a year (Hedlin et al.1980).

Douglas-fir Cone or Scale Midge

Midge larvae (*Contarinia oregonensis* or *C. washingtonesis*) were found in some Douglas-fir cones dissected on August 29 (figure 6). An adult midge was reared from cones collected August 28 and will be sent to a specialist for identification. The larvae of both species feed in cone scales and can destroy seed. Larvae drop to the litter and pupate. Adults emerge in spring when Douglas-fir flowers are open for pollination (Hedlin et al. 1980).

Figure 6. Orange colored Douglas-fir cone midge larvae.

Douglas-fir cone gall midge and seed chalcid have collectively destroyed 70% of Douglas-fir seed from California, Oregon, and Washington. Damage was more serious in coastal rather than inland areas (Schowalter et al.1985).

Douglas-fir Cone Moth

Douglas-fir cone moth (*Barbara colfaxiana*) is a common pest of Douglas-fir and has been found in many locations in Montana (Dewey 1972). It is reported as a major pest in some areas. Larvae can destroy 60-100% of the seeds in a cone. Infested cones may be misshapen with frass on the surface or may have no external evidence of damage. Adult moths are similar to coneworm moths but their fore wings are banded with brown, gray, and silver instead of only gray and silver. They emerge in the spring and lay eggs on cone bracts. Larvae are white, pinkish or yellowish. They pupate inside the cone and some may remain in extended diapause for one or more years (Hedlin et al. 1980).

We found a pinkish lepidopteran larva in one cone dissected on August 28 that is likely the Douglas-fir cone moth. However, no adults were reared out of any cones collected.

Other insects

Some small plant bugs (order Hemiptera) were reared out of western larch cones collected on August 28. These bugs have not yet been identified and their role in cone ecology is unknown.

Seed Yield

The yield from Douglas-fir cones collected from breeding zone 7A at Big Fork TIA was 0.079 pounds of seed per bushel of cones (table 1) which is about 10 times less than the average Douglas-fir yield of 0.5-0.8 pounds per bushel (Woody Plant Seed Manual USDA Ag Handbook 727). The yield from western larch cones collected ranged from 0.103-0.196 pounds of seed

per bushel of cones. Average yield from larch cones is a half a pound of seed per bushel (Woody Plant Seed Manual USDA Ag Handbook 727). The amount of this seed loss that is caused by insects at Big Fork TIA is not entirely known. Other factors such as lack of viable pollen can also reduce seed yield. However, the abundance of insects found at Big Fork TIA and available literature on cone and seed insects indicate that insects are likely causing considerable seed loss.

Table 1. Seed yield from cones collected at Big Fork TIA in 2012 (Coeur d'Alene Nursery Data).

Source ID	Species	Breeding Zone	Bushels	Lbs seed/ bushel
7608-12	DF	7A	3.5	0.079
7659-12	WL	MT low/mod	28.0	0.196
7628	WL	MT high	46.5	0.120
7635-12	WL	MT high	10.0	0.103

The most important and damaging insects found in western larch cones at Big Fork TIA were western spruce budworm, coneworms, and seed bugs. The most important insects found in Douglas-fir cones were western spruce budworm, coneworms, seed bugs, and seed chalcids.

Management Options

The most effective method of controlling insects in seed orchards is using an integrated pest management system which includes monitoring, sanitation (damaged cone removal), pheromones (when available), and correct timing of insecticide treatments when needed.

Since many insects spend the winter inside damaged cones, removing these cones each year will remove resident populations and should be done annually if possible. It may be difficult to accomplish damaged cone removal in western larch because of the small size of the cones. In addition, immigration of insects from any surrounding Douglas-fir, larch, spruce, or pine trees could be a continuous problem.

Insecticide Treatments

Considering the low levels of seed production found at Big Fork TIA in 2012, spraying with an insecticide should be part of an integrated pest management program developed for Big Fork in the future. Single or multiple applications of synthetic pyrethroids (permethrin and esfenvalerate) have been effective in reducing cone crop damage due to coneworms, seed bugs, cone midges, and seed chalcids (Haverty et al. 1986, Sandquist et al. 1993). However, multiple applications of these insecticides within a summer have sometimes led to outbreaks of scale insects in the Coeur d'Alene western white pine seed orchard. Other contact insecticides, such as carbaryl, would also likely be effective against many of the insects found.

Systemic insecticides can translocate into cones and kill cone and seed feeding insects while avoiding most non-target insects. The systemic insecticide, emamectin benzoate, has been shown to reduce the number of coneworm infested cones when injected into ponderosa pine (Cook et al. 2013) and reduced *Dioryctria* populations in loblolly pine (Grosman et al. 2002). However, while injecting systemic insecticides can useful in protecting cones of individual high-value trees, it would not be practical to use to protect an entire orchard.

Timing of insecticide applications is critical since many of the insects are protected once they bore into the cones (unless using a systemic insecticide). Timing must coincide with insect activity outside the cone which varies by insect species. Cone development has been used to time insecticide treatments for cone midges, seed chalcids, and coneworms (Johnson & Hedlin 1967, Overhulser & Sandquist 1985). We can also use pheromone traps to help time treatments (currently only available for coneworms). From 0 to 3 insecticide applications could be required to achieve crop protection (Overhulser & Sandquist 1985). If only a single application of insecticide is desired, Johnson & Hedlin recommend spraying when the cones are pendent to half full length in development.

To protect against western spruce budworm damage, application of the insecticide needs to coincide with Douglas-fir cone bud burst which is usually several weeks earlier than vegetative buds. Spraying should be done when cones are about one inch long (when the seed cones begin to elongate but before pollination is complete). The entire tree should be sprayed with high-pressure spray equipment to reach the top and needs to be applied to all of the foliage to the point of run-off (Stipe 1984).

Considering insect biology, pheromone trap data, and cone development, optimum timing of insecticide treatment for the most important insects found at Big Fork TIA is shown in table 2.

Table 2. Optimum timing of insecticide treatment for important cone and seed insects at Big Fork TIA.

Insect	**Target Timing of Insecticide Treatment**
Spruce Budworm	Early June
Coneworms	Late-June to mid-July or mid- to late-August
Seed Bugs	June through August
Seed Chalcids	1 or 2 weeks after cones turn pendent

Recommendations

Because of the importance of Douglas-fir and larch seed produced at Big Fork TIA and the extent of insect damage found in 2012, we recommend at least two insecticide treatments in 2013—one in early June for spruce budworm and seed chalcids and one in mid-July for coneworms and seed bugs. If necessary, a third treatment could be applied in August if additional seed bugs are found.

Sanitation of damaged cones should occur whenever possible to remove any overwintering insects. Monitoring coneworms with pheromone traps annually from June through early September will help monitor population levels and in the timing of insecticide treatments.

FHP will continue to be involved in monitoring cone and seed insects, determining the proper timing applications of insecticides, and conducting follow-up monitoring on treatment effectiveness.

Acknowledgments

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